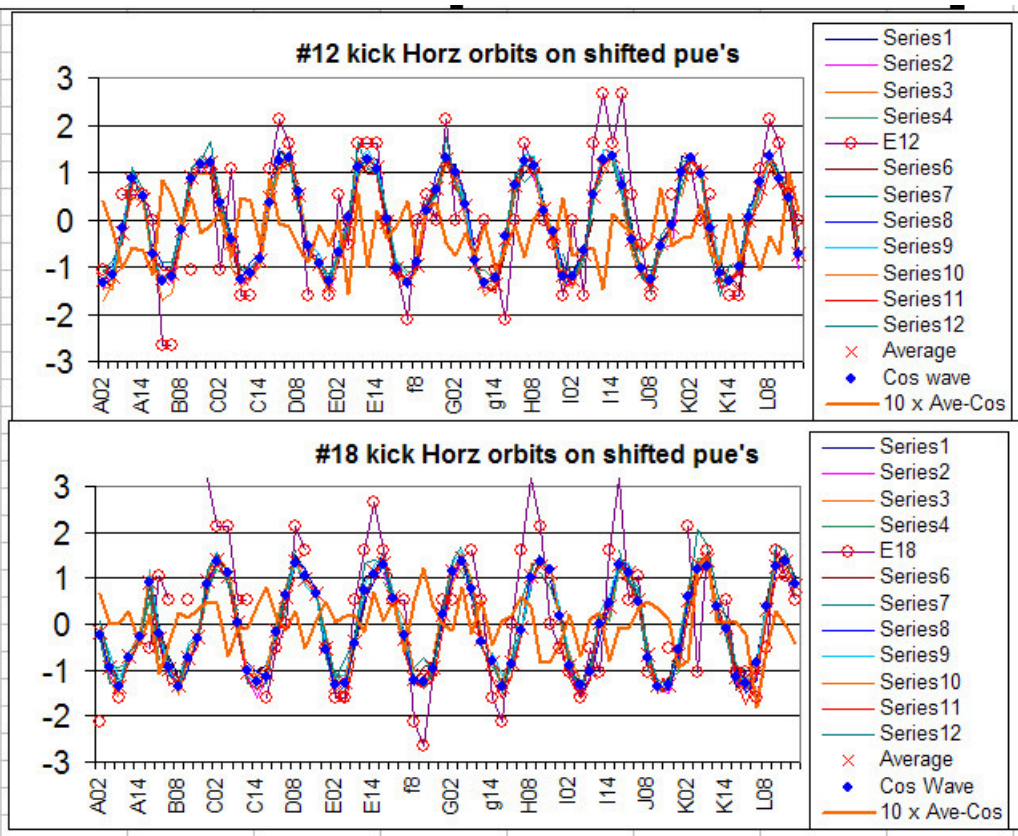
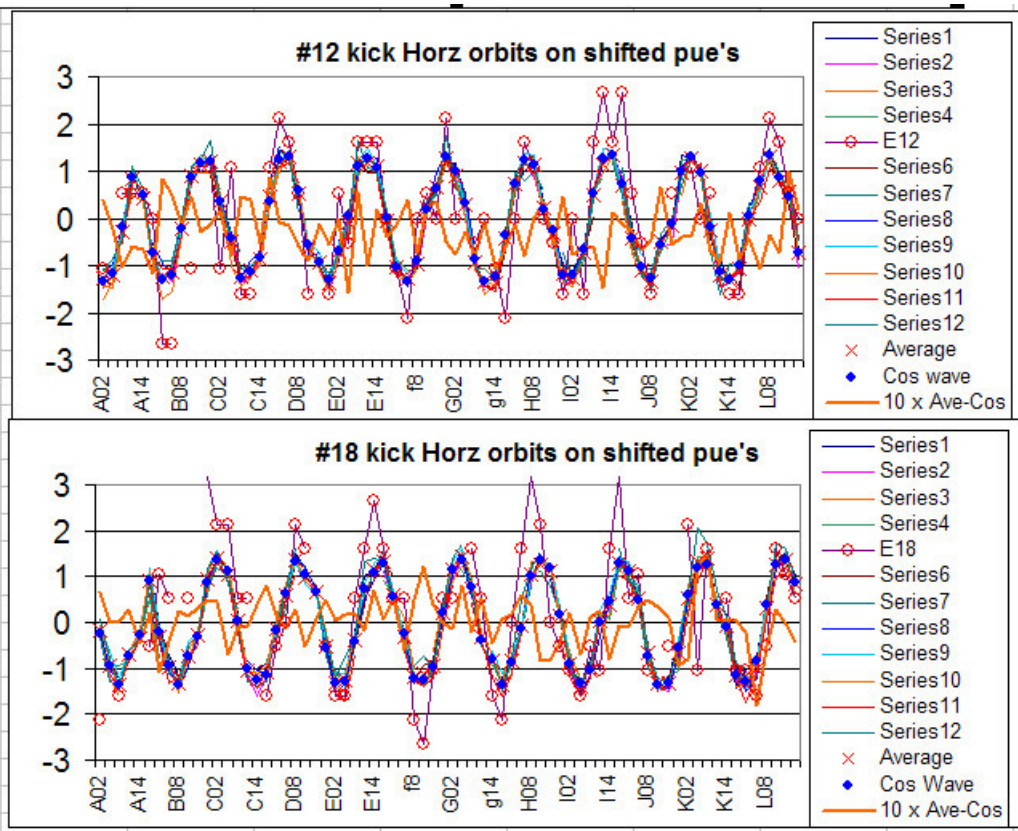


### Reduction of some of the ORM data:

This entry includes FT energy bare AGS Horz & Vert and also Injection energy bare AGS H only. This data was taken during Run'07, The FT data set with gold the injection set with protons.

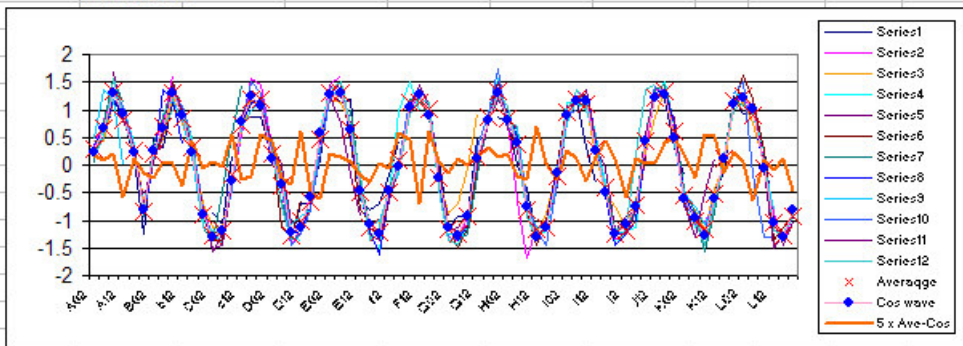
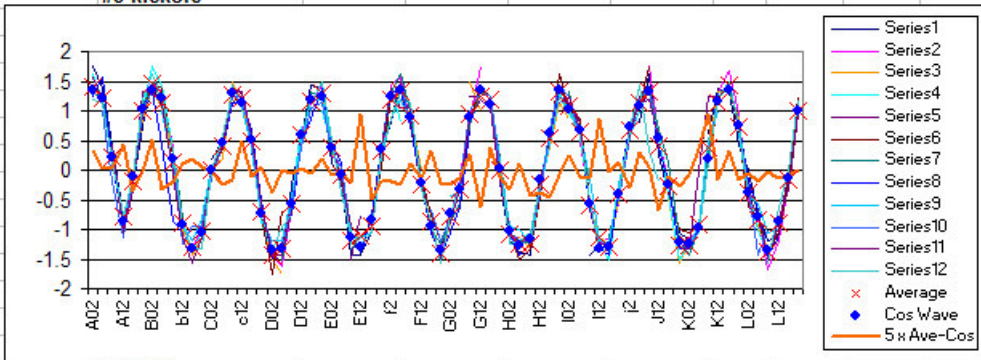
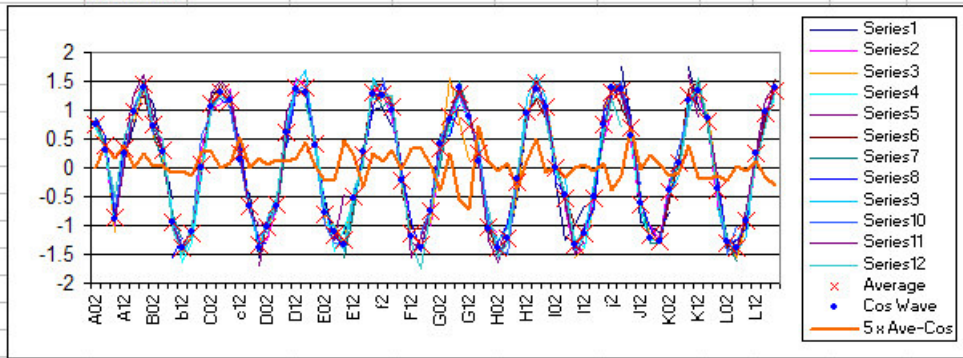
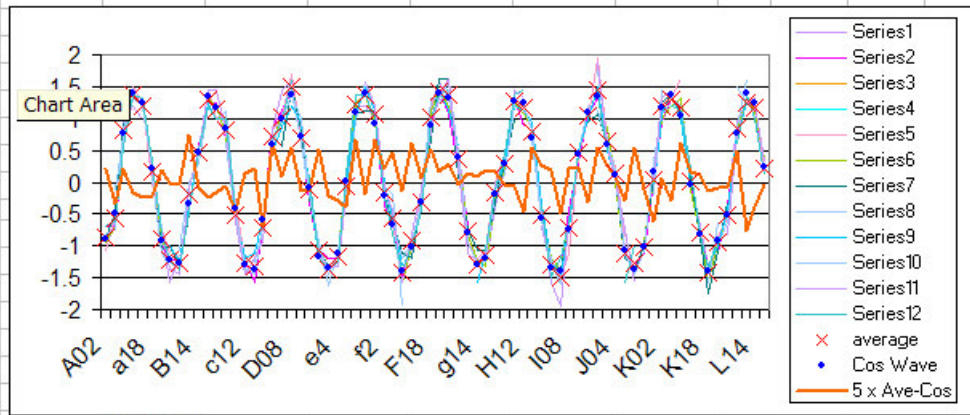
Reduction was based on an assumption that the AGS is super period symmetric; this assumption was checked as shown. The modeled betas at the pue's are within 2% of each other, thus the same beta was used for all as the 1% difference in gain for a 1-3 cm wave would not be determinable.



The orbits for the four different kicker dipoles in a super period are plotted. For the #2 kicks the orbit for the B2 kicker was 'left shifted' one super period so the cusps would line up. The subsequent #2 kick orbits were also super period shifted to line all the cusps up. The color of each line between points for each orbit are kept light so one can see possible 'outliers'. The orbit for the E2 kicker is obviously bad data and ignored in the plotted average of points. The

rms error of the average is about 175 microns, or 6% of the p-p amplitude. Some outrider points on other orbits were also dropped. Also plotted are points for a simple 'cosine wave' assuming an arbitrary tune, phase of the pue's & kick, and an amplitude; all fit by hand reducing the rms error to about 50 microns. The best fit came with the tune as MODELED not as measured, a 9 'milli-Q' difference, the error of fit was 10% greater using the measured tune. The phases of the kicks came within half a milli-radian of the modeled values; the amplitudes the same within 1.4%, but 12% less than a value based on estimated kick strength, and modeled tune & beta. The phases of the pue's were modeled values and NOT fit as this is beyond the scope of these tools, thus there could be some tilt toward good agreement with the model. The error between the average of the orbits and the cos wave is also plotted TEN TIMES the actual value.

## Vertical orbits from vert kicks

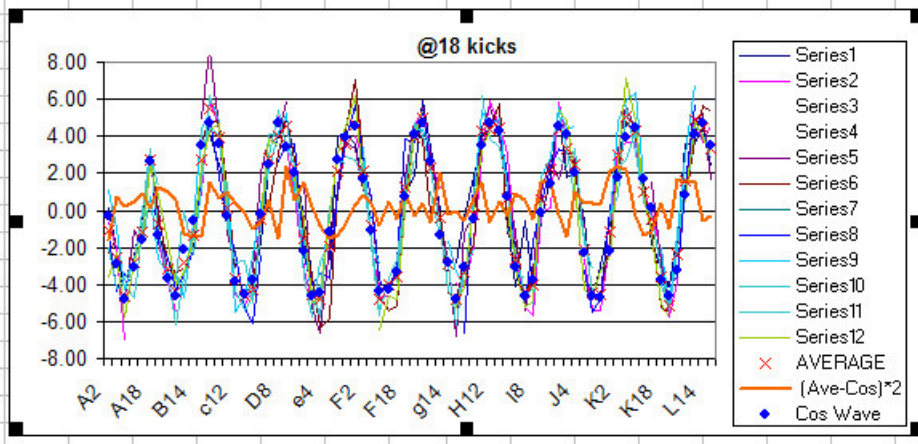
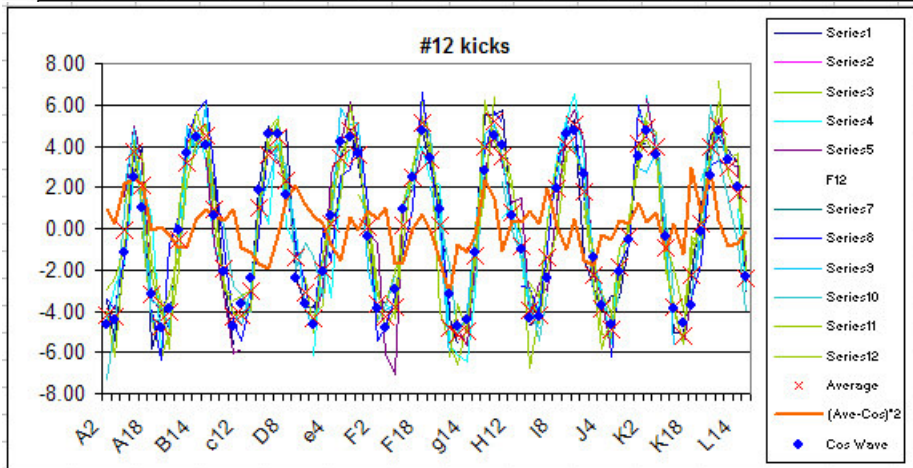
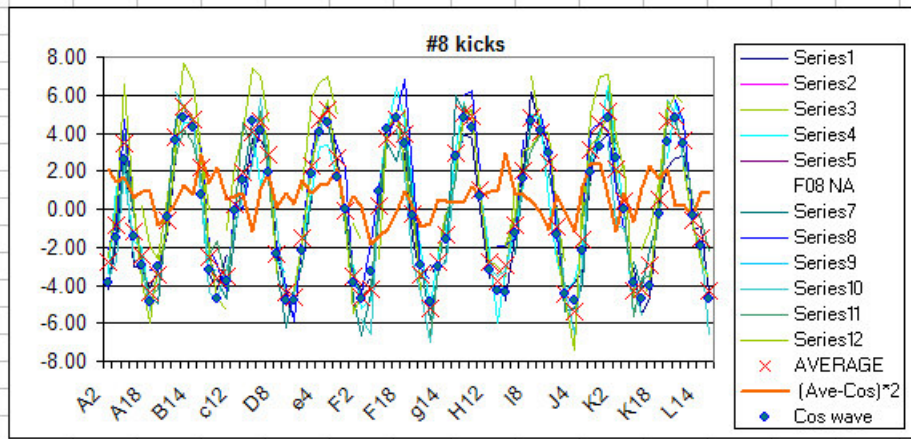
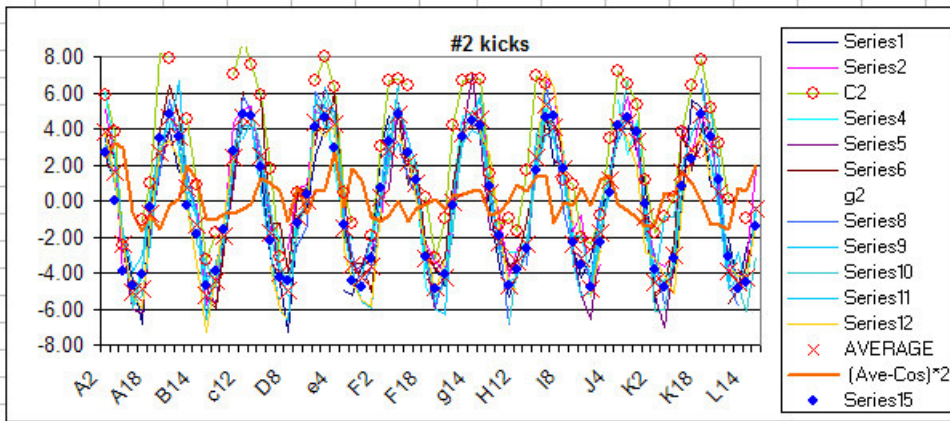


Vertical ORM data was reduced in the same fashion. Here the fit was still to modeled values of tune and phase of the kickers – again measured tunes caused a 10% rise in rms error of data to cos wave for the 0.01 tune difference. The rms error between averages and data was a bit more, about 185 microns or again about 7% of p-p amplitude. The data, or super period symmetric assumption, is probably not as good as the fitted phases to modeled phase had 3 milli-radian error and the fitted kick amplitude varied 3.4% from set to set; again the amplitude of the oscillations were about 12% less than expected.

In summery, I feel that the extraction energy AGS model is good and the bare machine is super period symmetric to about 15% possible errors in beta. The fact that the data is better fit to modeled tunes than measured tunes may be due to a coupling problem with the Horz & Vert tunes so close.

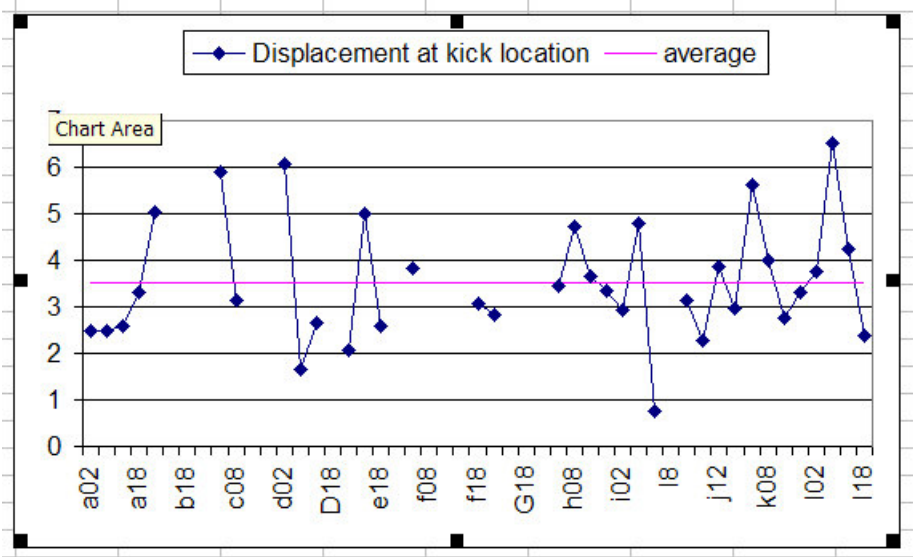
Injection field ORM data reduction:



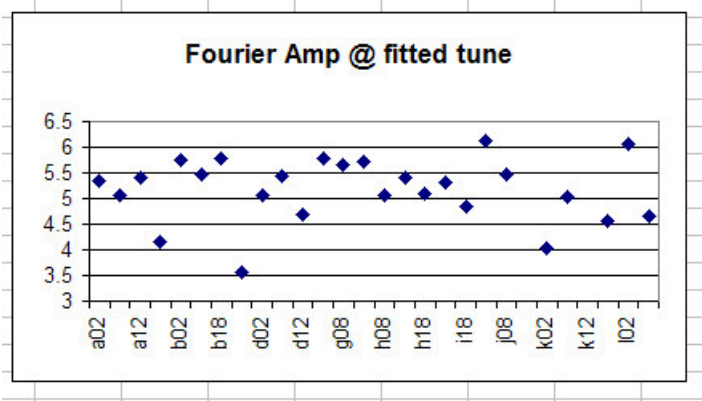


At injection the uniformity is not as good. The rms error between the average of the number 2, 4, etc. kicks for the 12 super periods and the data is over a mm out of the 9 mm p-p oscillation, or 12% twice as poor as at extraction energy. The fit to simple cos waves for each class of kicks was reasonably close to the model, 1% variation in amplitude and 11 milli-radians in phase variation from then model. Again the tune came very close to the model. A tweek of 3 milli-Q's slightly reduced the error data to cos wave but the measured tune was .042 different, comparable to the .047 modeled difference between H&V tunes, but less than the measured divergence of .022 tune units. I still wonder that the modeled tune fits the data better than the measured tune. A check of the process is to use a tweaked model that gives the measured tune and see if that improves the fit between modeled cos wave and data.

Other tests for super period symmetry:



The above is a plot of the pue's displacement at the location of the kick. If there is a beta wave this displacement would be equal to beta at that location [ $\sqrt{\beta^* \beta}$ ], no periodic pattern is seen, but there is a LOT of noise.



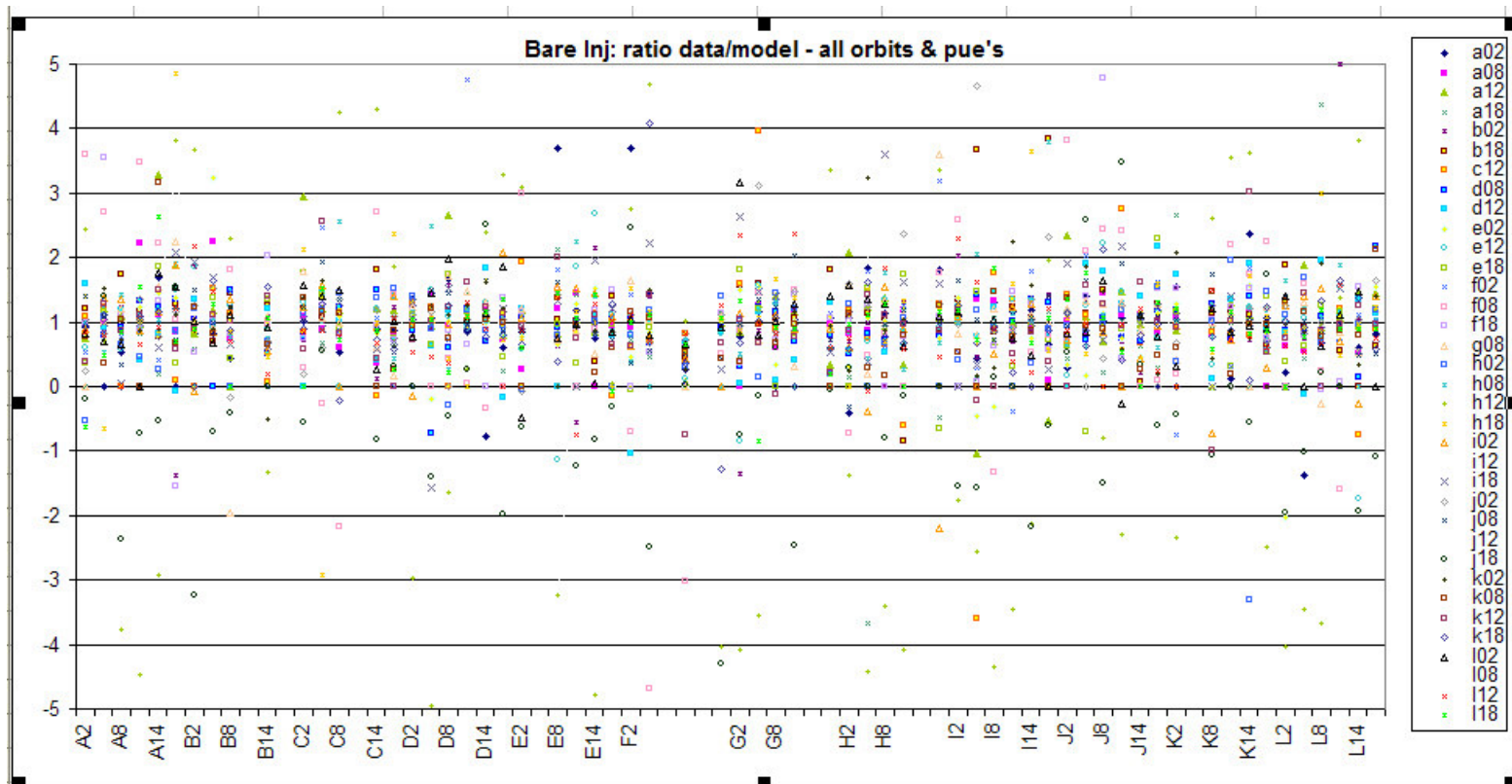
Data

|     |         |
|-----|---------|
| a02 | 5.34117 |
| a08 | 5.06726 |
| a12 | 5.39063 |
| a18 | 4.15931 |
| b02 | 5.7359  |
| B12 | 5.46195 |
| b18 | 5.7928  |
| B8  | 3.56396 |
| d02 | 5.07259 |
| d08 | 5.44136 |
| d12 | 4.69115 |
| e12 | 5.7691  |
| g08 | 5.67069 |
| h02 | 5.7154  |
| h08 | 5.07503 |
| h12 | 5.40356 |
| h18 | 5.10078 |
| i12 | 5.30062 |
| i18 | 4.8377  |
| j02 | 6.1218  |
| j08 | 5.45382 |
| j12 | 0.81499 |
| k02 | 4.02021 |
| k08 | 5.04359 |
| k12 | 0.30923 |
| k18 | 4.56432 |
| l02 | 6.07059 |
| l02 | 4.65434 |
| l08 | 5.49426 |
| l12 | 4.75124 |
| l18 | 5.57939 |

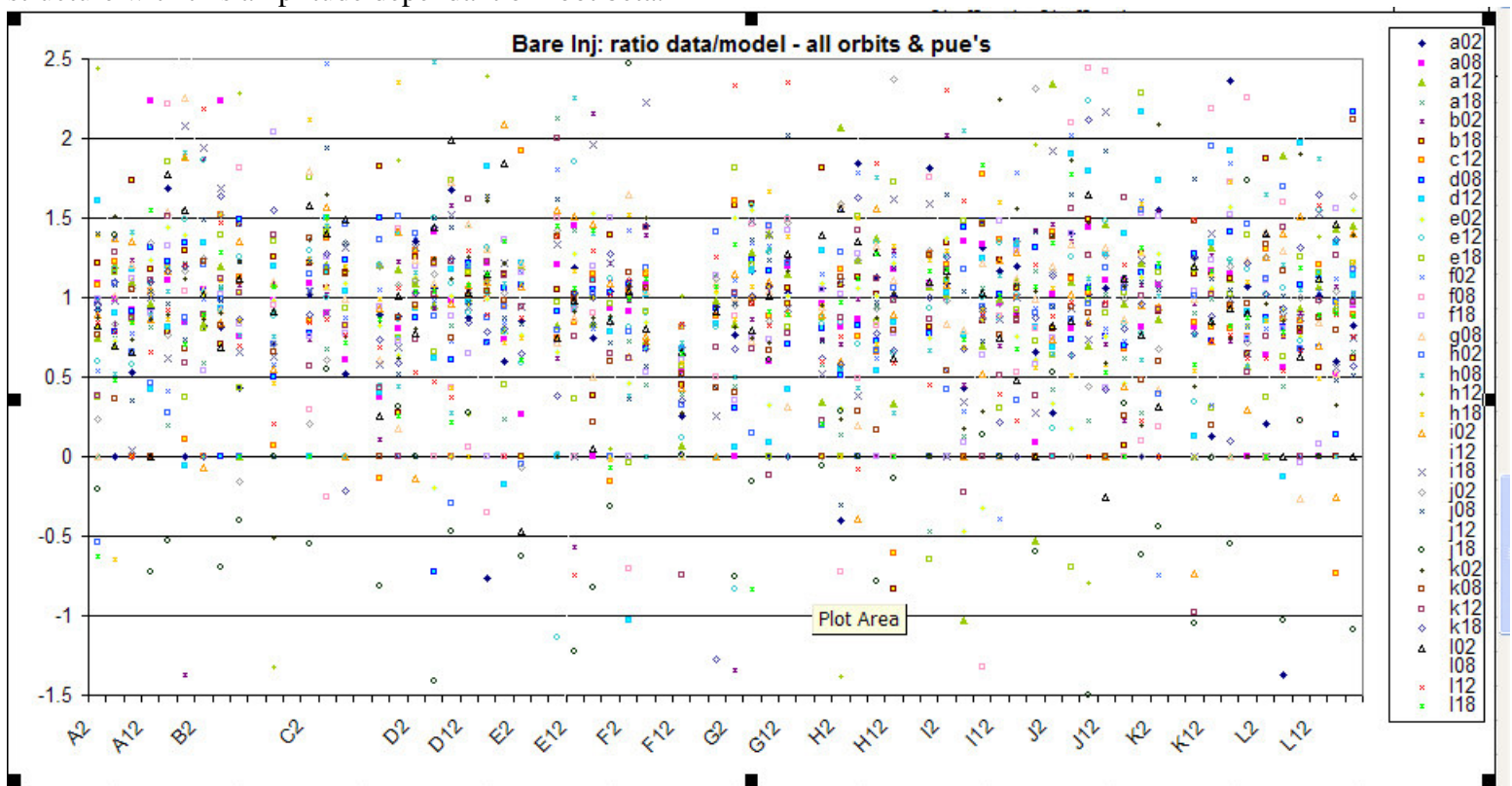
The amplitude of the Sine wave at the tune frequency was calculated. The super period shifted orbits were used so all orbits had their cusps in the first super period, there would be a slight reduction in apparent amplitude for the latter kicks due to interference from the out of phase wave in the first couple of electrodes, eg.: the first 5 or so pue's data would be  $\sim 100^\circ$  out of phase with the remaining 60 odd electrodes. The data set is not complete, so the data table is included. This 10-15% pattern is not seen nor is there any obvious periodic wave. This test uses more data than the above but is only sensitive to  $\sqrt{\beta}$ .

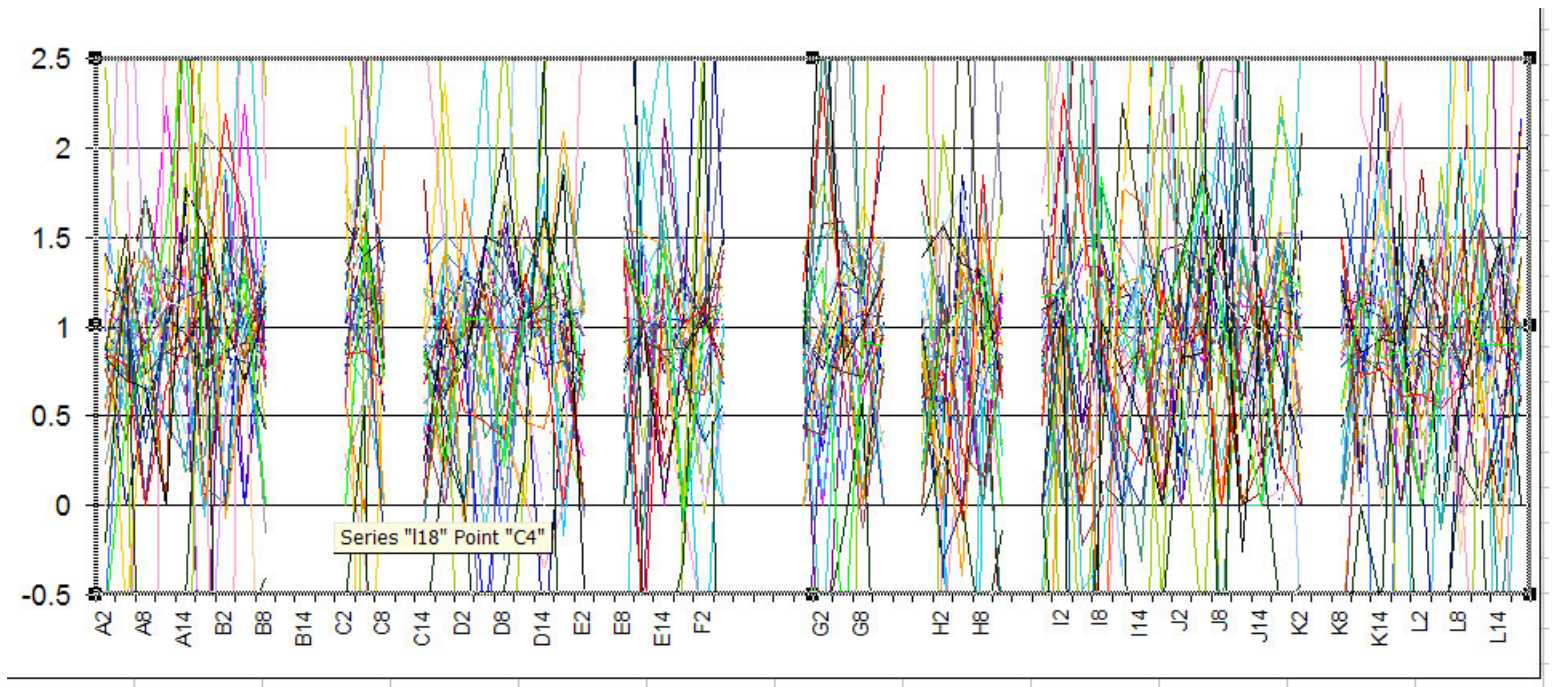
Point by point comparison of data to cos wave





This shows most of the data points, not super period shifted, divided by the cos wave amplitude at that pue. Not plotted are points where the modeled cos wave was less than 0.4, ~10% of the wave amplitude. Again less than a 10% structure with this amplitude dependant on root beta.





These are blowups of the data, still no obvious structure. Also plotted are the lines that connect the data points. This indicates mostly noise as the lines are not steady but randomly bounding up and down.

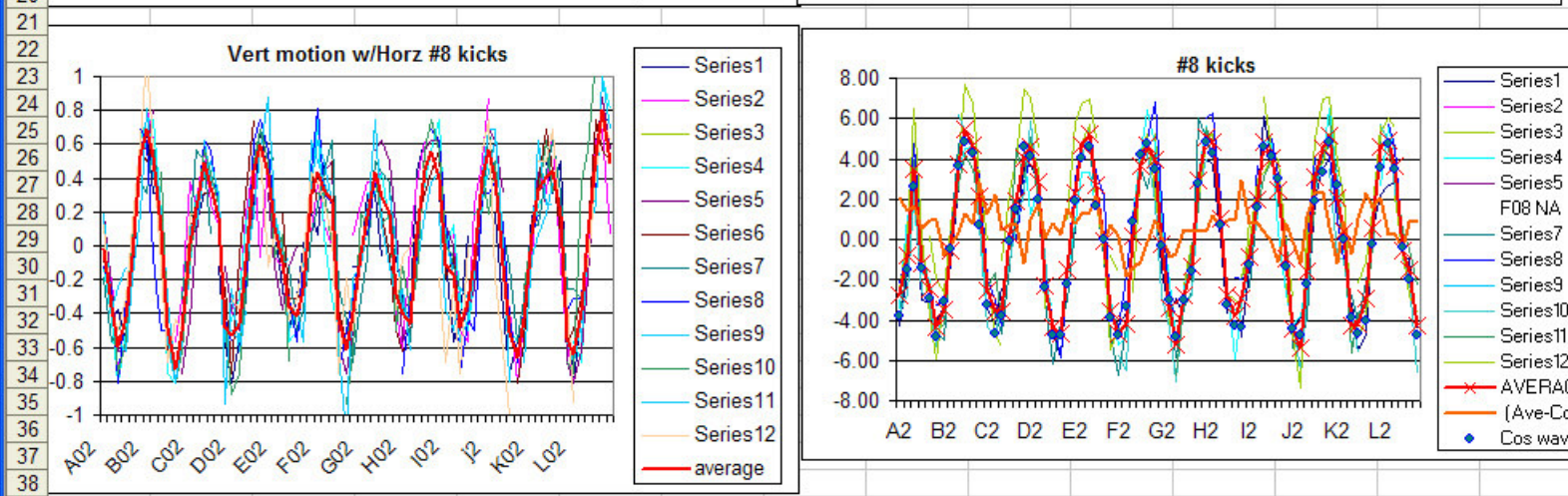
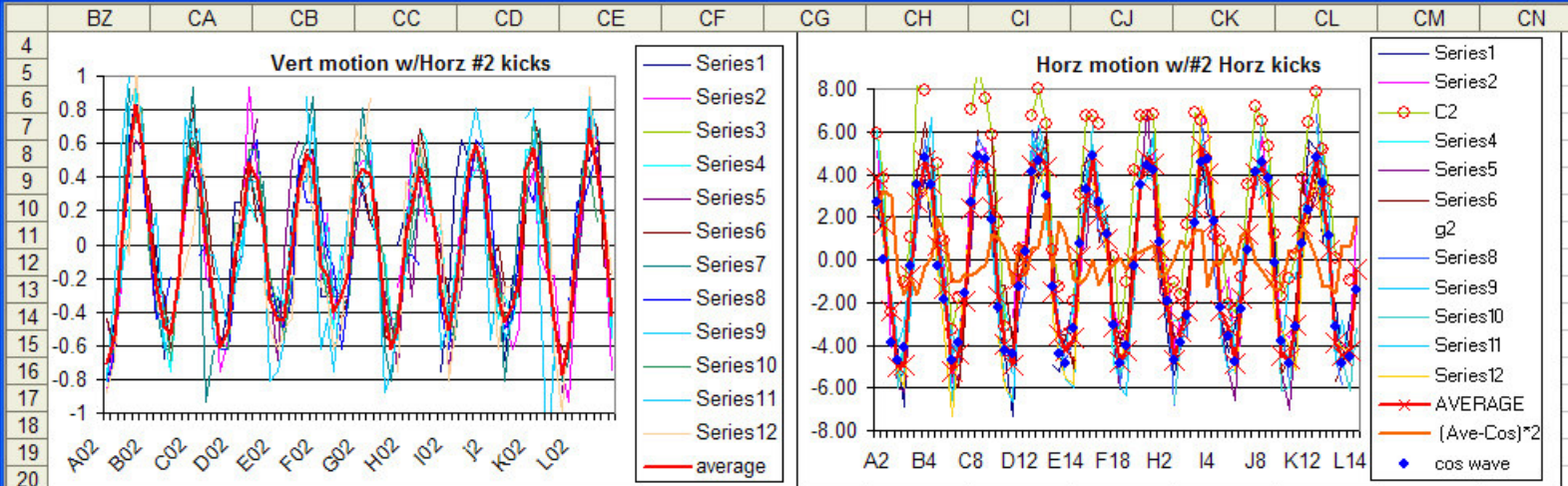
### Conclusion:

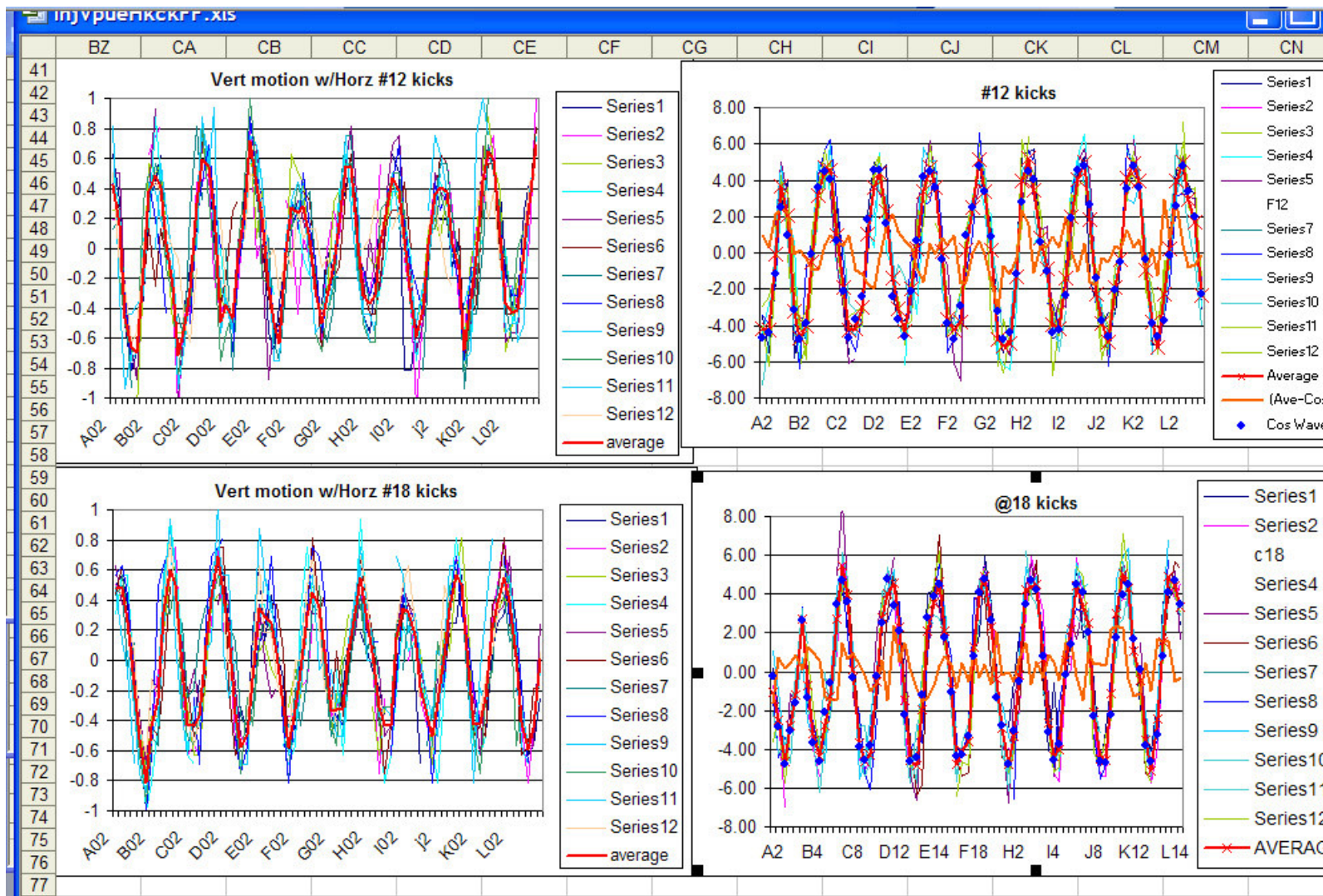
Thus the data on hand seems consistent with a super period symmetric AGS to beta being reproducible to the 15% level. This judgment may prove useful to those trying the ORM machinery to analysis the AGS in more detail.

### Coupling as measured with the injection data:

Here the vertical motion caused by Horz kicks is shown. Again using the method of overlaying orbits by shifting the orbits as the kicks are shifted from one super period to another, the orbits and averages are plotted. Included are plots of the Horz motion from the same kicks.

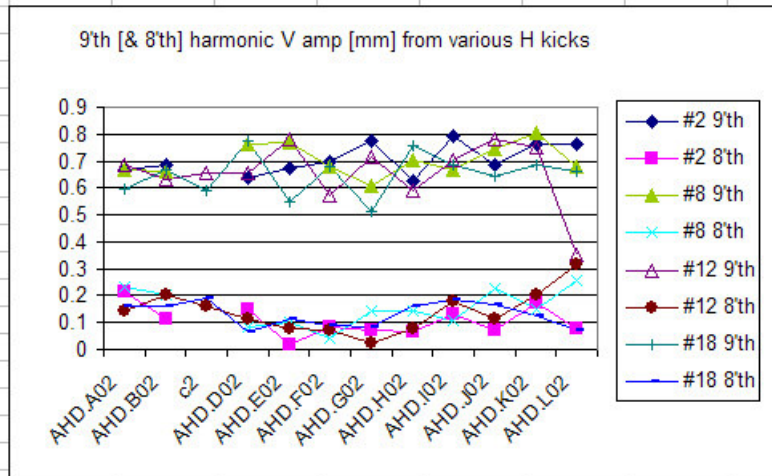






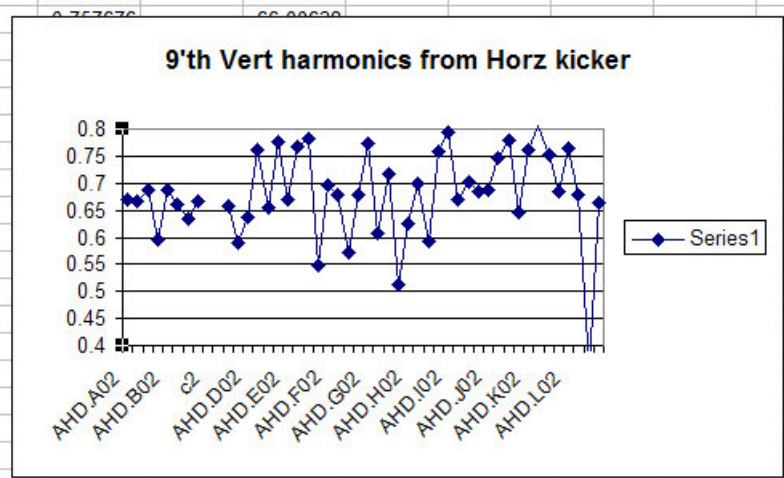
These plots show that the coupling in the AGS is ‘super period symmetric’, indicating a global error in msny of the AGS magnets. The AGS ‘should’ be flat with out coupling This is not expected as I had postulated a few magnets had been abused to cause sag and the resultant roll causing the previously observed coupling.

To further check the similarity between super periods, the ninth and eighth harmonics of the orbits were calculated and plotted for all the orbits. Here the harmonics are grouped on the magnet number in a super period. There were variations but these do not appear to be periodic.

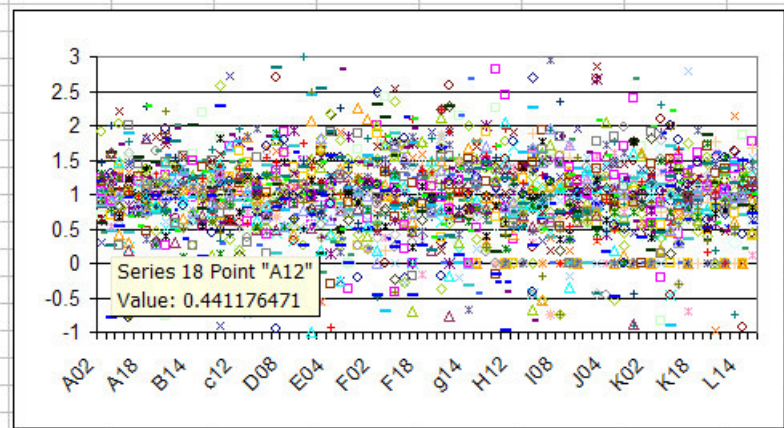




Here the harmonics are grouped on the magnet number in a super period.



Here the 9'th for sequential kick magnets around the ring.

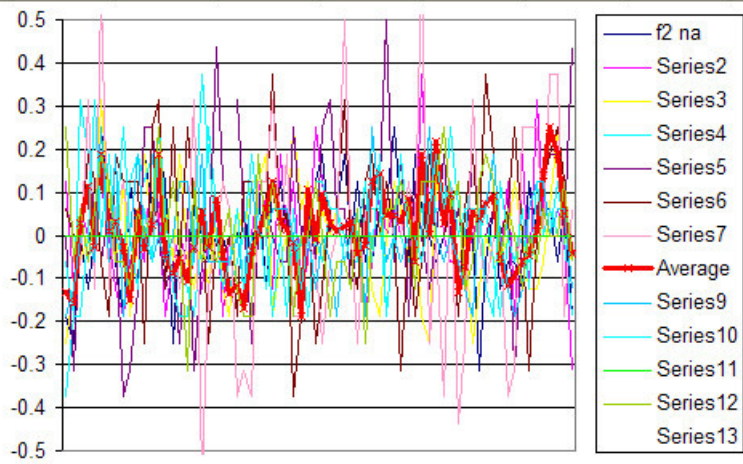


And the scatter around their averages for the various pue's.

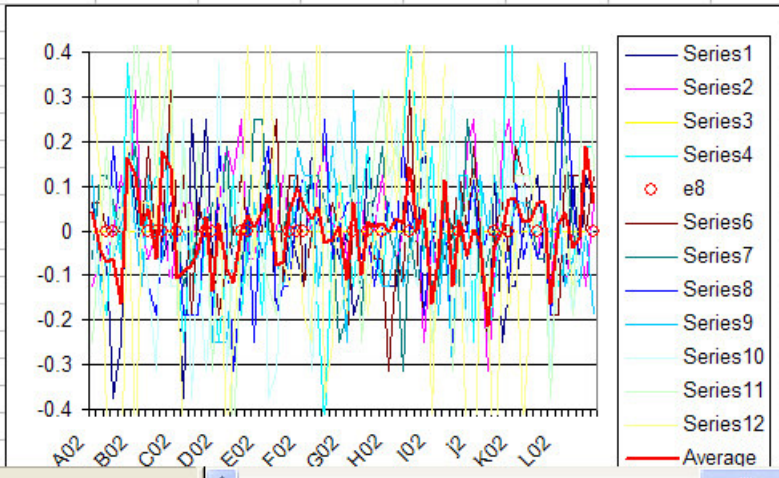
High energy coupling:.

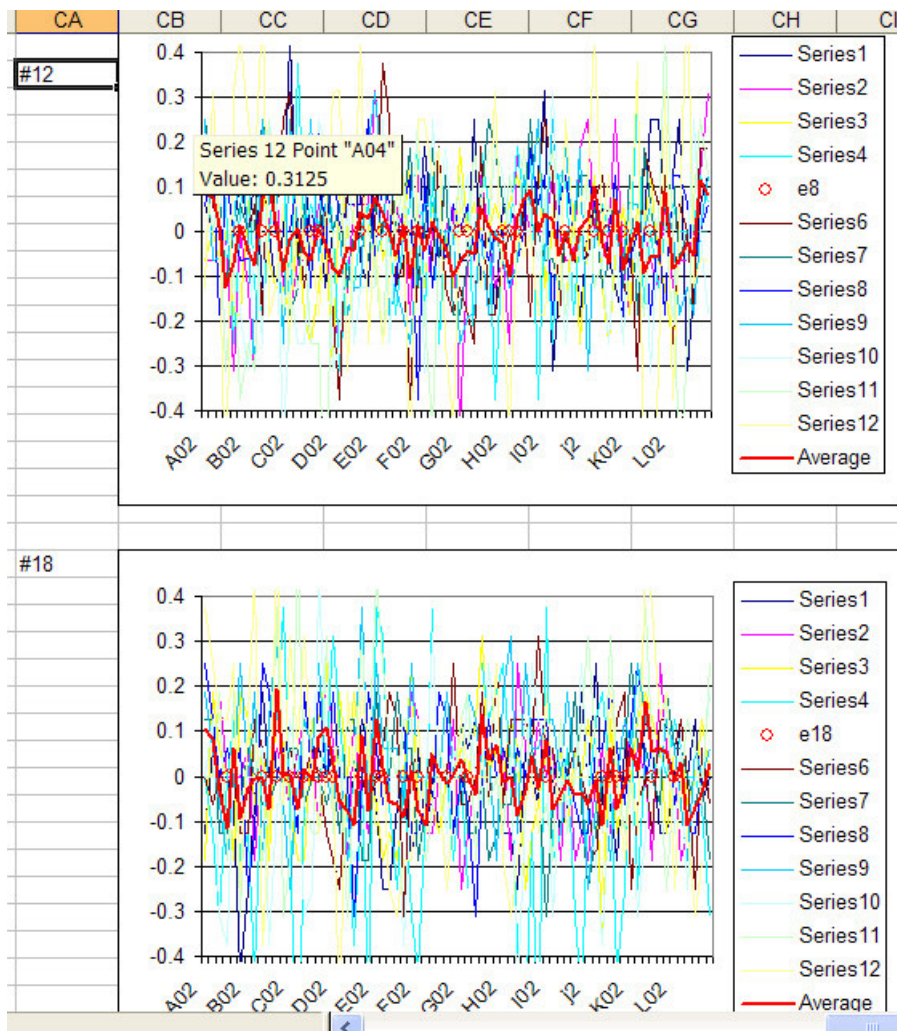


#2



#8





The high energy ORM has the same information, BUT with 0.2 mm of random errors, no statement about coupling can be made. Special tests at high energy could be done, but will require a few hours of AGS time to setup.

Conclusion: The coupling at injection solidly appears to ge a ‘global’ phenomena, not due to a few local couplers. This statement only holds at this time for the injection ORM data. The high energy coupling data is too ‘noisy’ to make a judgment.